

March 1996

Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
1261 Duck Road
Duck, NC 27949-4472

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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

These reports are now available via the World Wide Web at
<http://frf.wes.army.mil/frf.html>

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Your comments and criticisms are welcome.

Introduction

1

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511 (baron@duck.wes.army.mil).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

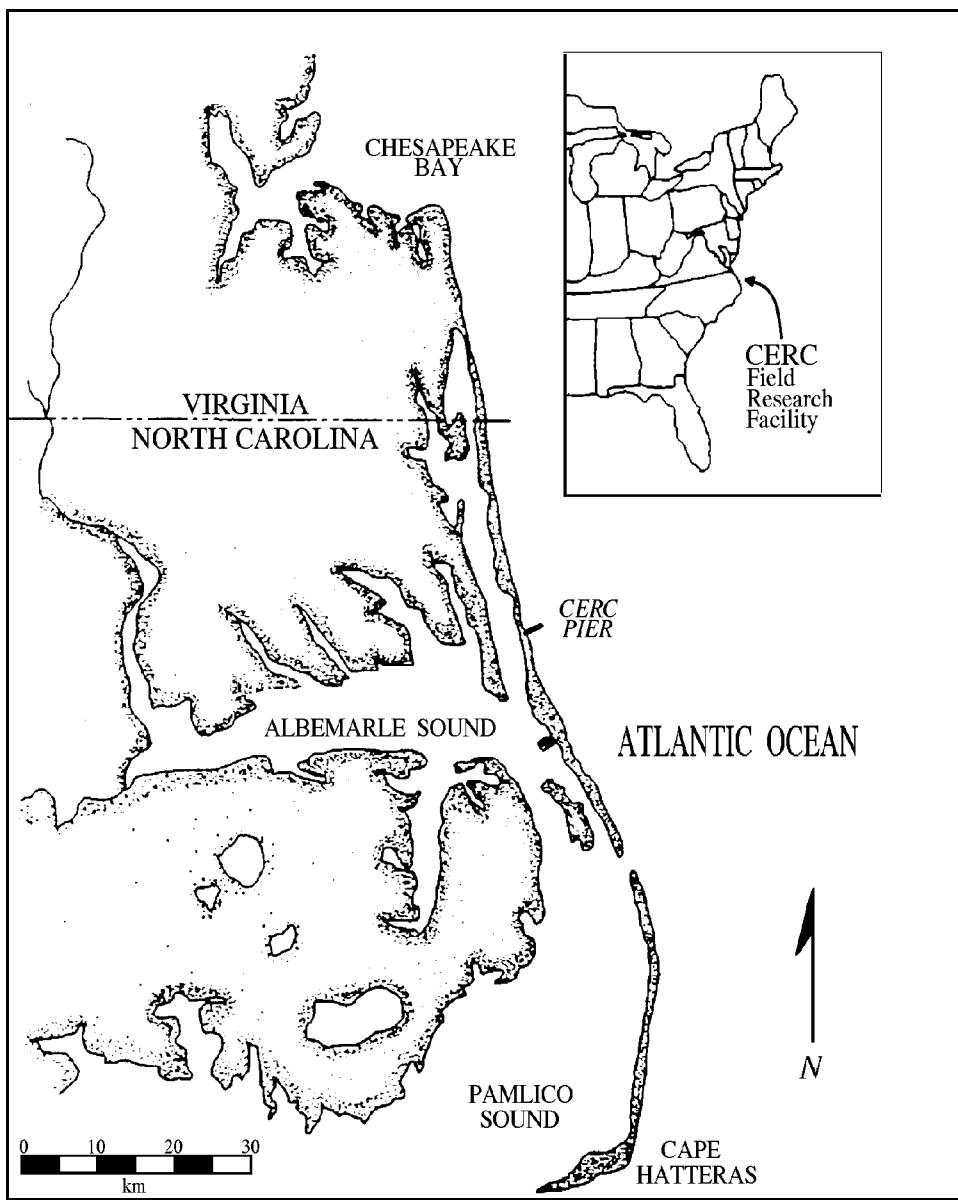


Figure 1. FRF Location Map

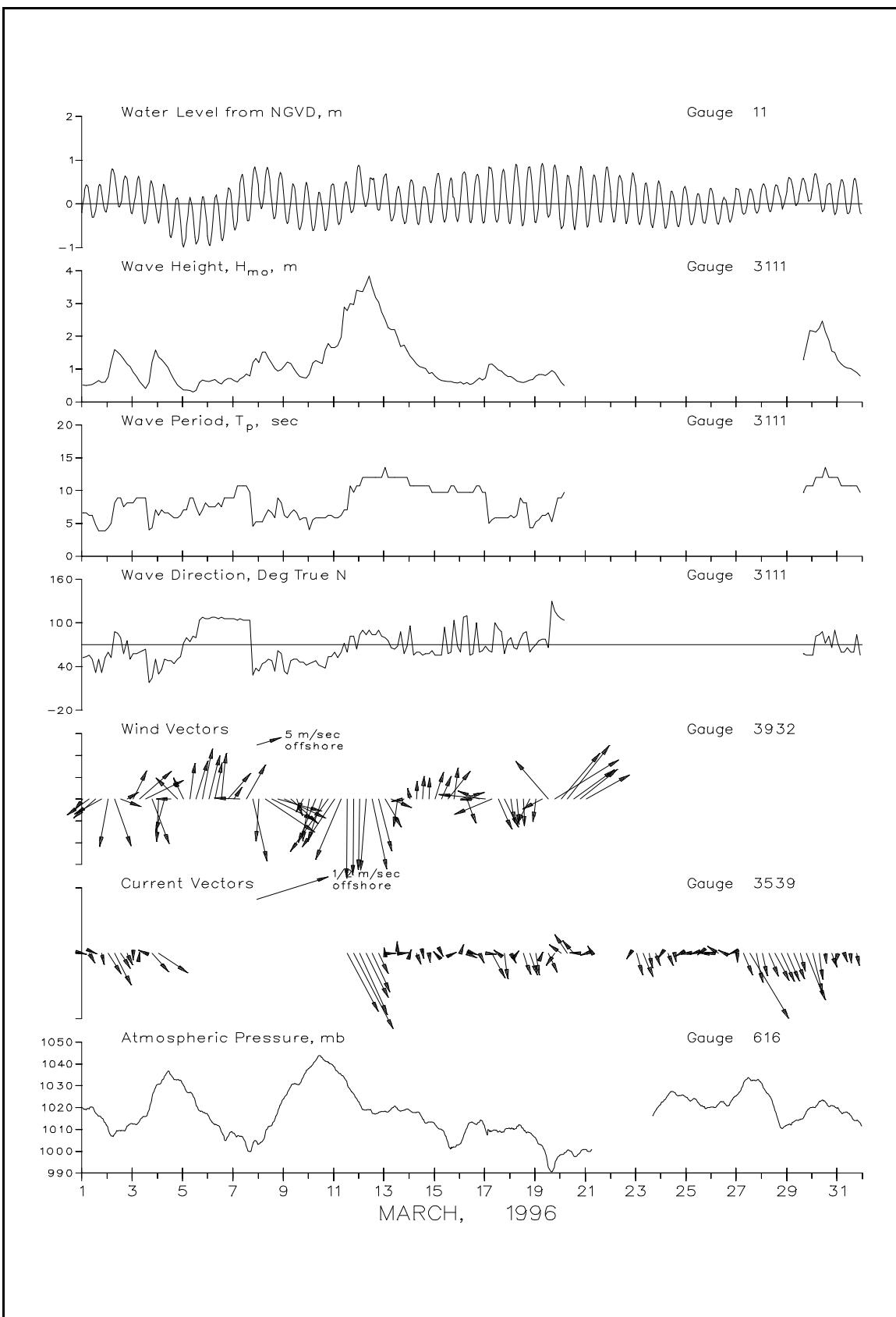


Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

		March 1996																															
		Day of the month																															
Gauge ID	Description/Remarks	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	/	*	*	*	*	*	*	*	*	
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	/	*	*	*	*	*	*	*	*	
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	-	-	-	-	-	-	-	-	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	-	-	-	-	-	-	-	-	-	
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	/	*	*	*	*	*	*	*	*	
625	Baylor staff on FRF pier	Gauge Status	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
		Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	-	-	-	-	-	/	*	*		
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	/	/	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-	-	/	*	*	*	*	*	*		
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	/	-	-	-	-	-	/	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*		
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Visual Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Gauge Status * = Operational / = Partial - = Non-Operational																																	
Data Collected * = All / = Partial - = None																																	
Visual Observations * = Complete / = Partial - = None																																	

Table 2
Gauge Locations

Gauge*	Description	* Latitude	* Longitude	* FRF Coordinates	* Gauge Depth	* Water Depth
ID *		* Degrees N	* Degrees W	* CrossshoreT Longshore*	NGVD, m	* NGVD, m
		*	*	*	m	*
616	* Atmospheric Pressure*	36 10' 57.03"	* 75 45' 5.50"	* 11.60	* 569.00	* -----
3932	* Anemometer	* 36 11' 1.23"	* 75 44' 43.07"	* 585.20	* 517.30	* 19.50
641	* Pressure Gauge	* 36 10' 57.71"	* 75 44' 56.23"	* 239.11	* 516.64	* -1.64
625	* Baylor Staff	* 36 11' 1.04"	* 75 44' 43.72"	* 568.00	* 516.64	* Surface
3111	* 8 Meter Array North	* 36 11' 19.14"	* 75 44' 36.41"	* 915.23	* 990.16	* -7.50
	* 8 Meter Array South	* 36 11' 11.28"	* 75 44' 33.28"	* 914.20	* 735.37	* -7.42
	* 8 Meter Array East	* 36 11' 13.70"	* 75 44' 32.56"	* 954.51	* 800.58	* -7.62
	* 8 Meter Array West	* 36 11' 12.48"	* 75 44' 37.11"	* 834.66	* 800.37	* -6.98
111	* Pressure Gauge in center of 8 M Array	* 36 11' 14.06"	* 75 44' 34.39"	* 914.43	* 825.52	* -7.76
630	* Waverider Buoy	* 36 10' 5.10"	* 75 41' 59.30"	* 3934.96	* -2400.81	* Surface
3539	* Current Meter	* 36 11' 23.57"	* 75 44' 9.12"	* 1605.80	* 907.60	* -11.60
11	* NOAA Tide Gauge	* 36 11' 1.25"	* 75 44' 42.60"	* 596.49	* 514.20	* Surface
R	R	R	R	R	R	R

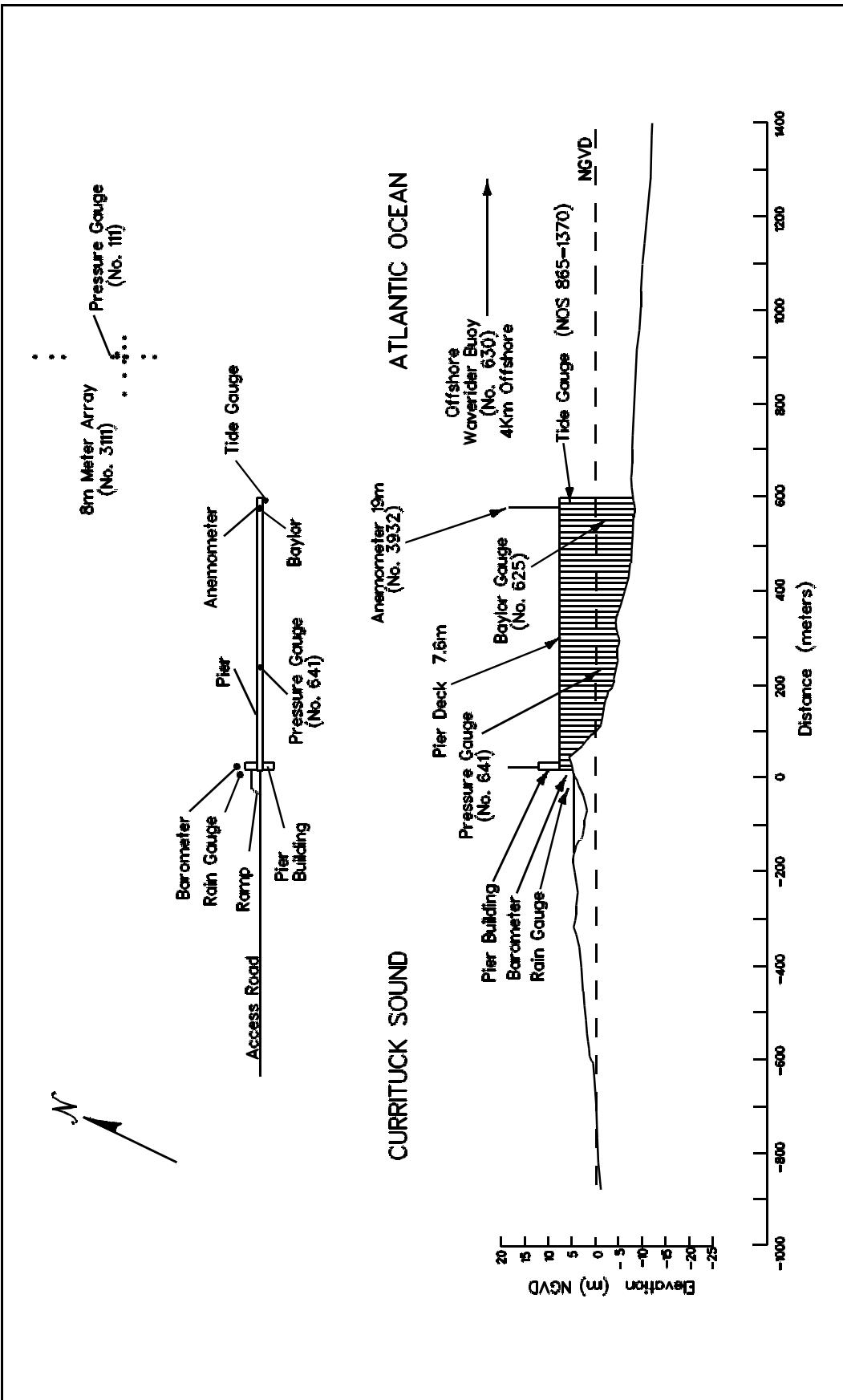


Figure 3. Instrument Locations, Elevations From NGVD

Meteorological Data

2

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

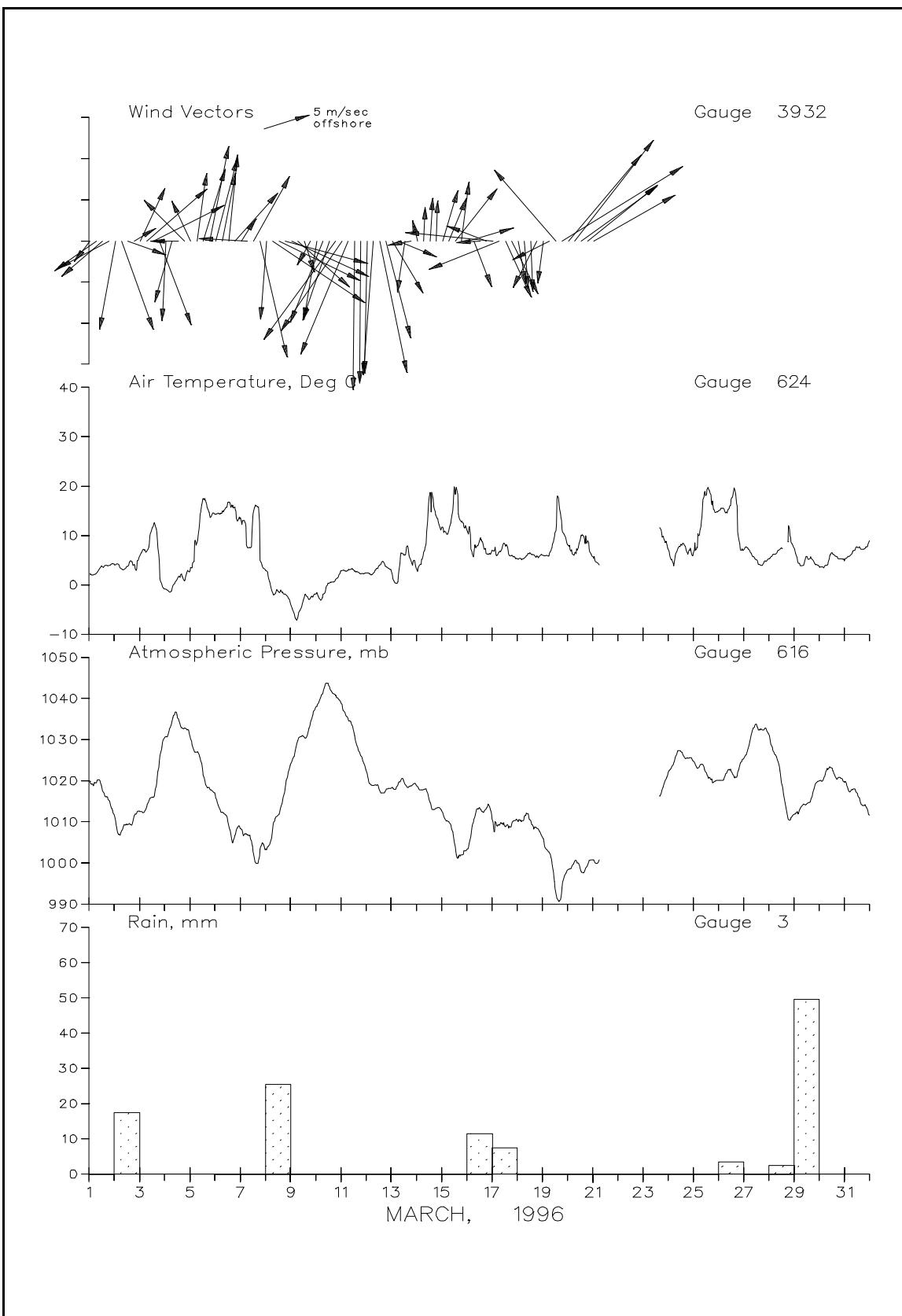


Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Mar 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	3	1	2.2	1019.9	0
	700	6	50	2.3	1019.5	0
	1300	6	45	3.7	1017.6	0
	1900	6	57	4.0	1015.3	0
2	100	11	8	4.0	1010.3	0
	700	11	342	3.2	1007.9	18
	1300	4	293	3.7	1009.3	0
	1900	3	236	4.2	1011.5	0
3	100	7	202	6.0	1012.5	0
	700	9	224	6.8	1013.8	0
	1300	9	240	11.9	1016.0	0
	1900	11	341	4.6	1024.9	0
4	100	10	2	-0.9	1030.9	0
	700	8	1	-0.9	1034.5	0
	1300	3	88	1.7	1035.0	0
	1900	6	139	0.8	1032.9	0
5	100	5	157	3.6	1030.2	0
	700	8	186	8.6	1027.0	0
	1300	9	194	17.5	1021.4	0
	1900	12	189	14.0	1018.1	0
6	100	10	192	14.4	1015.9	0
	700	8	189	14.9	1012.5	0
	1300	10	185	16.8	1009.0	0
	1900	7	217	15.8	1006.9	0
7	100	3	210	12.9	1008.3	0
	700	5	92	7.5	1006.8	0
	1300	9	205	14.9	1002.2	0
	1900	14	348	5.0	1003.4	0
8	100	10	3	2.8	1003.3	0
	700	12	307	-1.5	1008.3	25
	1300	10	299	-1.5	1011.9	0
	1900	9	287	-1.9	1018.3	0
9	100	9	298	-4.6	1024.7	0
	700	8	315	-6.6	1029.8	0
	1300	4	344	-2.5	1030.7	0
	1900	3	25	-2.7	1034.1	0
10	100	10	8	-1.6	1038.2	0
	700	10	19	-1.9	1041.5	0
	1300	10	16	0.4	1042.9	0
	1900	14	32	1.0	1040.6	0

Table 3
Meteorological Data (continued)

Mar 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	13	30	3.0	1038.6	0
	700	15	19	3.1	1035.1	0
	1300	18	1	2.8	1031.1	0
	1900	17	1	2.2	1026.2	0
12	100	16	1	2.5	1021.7	0
	700	16	3	2.4	1018.9	0
	1300	16	349	4.0	1017.5	0
	1900	12	347	3.7	1017.7	0
13	100	7	333	2.0	1018.4	0
	700	4	296	2.0	1019.5	0
	1300	6	7	6.1	1019.2	0
	1900	2	77	4.8	1018.8	0
14	100	3	168	2.7	1018.7	0
	700	4	182	6.6	1017.9	0
	1300	5	183	18.7	1014.8	0
	1900	5	181	14.0	1013.4	0
15	100	6	194	11.6	1012.3	0
	700	5	199	11.0	1010.1	0
	1300	8	214	18.3	1004.1	0
	1900	7	186	12.8	1002.1	0
16	100	5	251	10.5	1003.6	0
	700	6	341	6.6	1010.8	11
	1300	2	1	9.6	1013.1	0
	1900	5	113	6.3	1013.4	0
17	100	9	96	6.9	1010.0	0
	700	8	64	6.6	1009.3	8
	1300	7	338	7.9	1008.9	0
	1900	7	336	6.0	1009.5	0
18	100	5	351	5.2	1010.1	0
	700	6	356	5.5	1011.3	0
	1300	6	358	6.3	1010.3	0
	1900	6	24	5.9	1008.5	0
19	100	5	6	5.9	1006.0	0
	700	4	59	6.4	1002.5	0
	1300	11	143	11.0	992.6	0
	1900	15	234	11.3	994.1	0
20	100	13	216	7.9	998.5	0
	700	15	213	6.4	1000.5	0
	1300	10	230	10.1	998.0	0
	1900	10	227	9.0	999.5	0

Table 3
Meteorological Data (concluded)

Mar 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	10	236	5.4	1000.8	0
	700				0	0
	1300				0	0
	1300				0	0
	1900				0	0
22	100				0	0
	700		Hardware Error		0	0
	1300				0	0
	1900				0	0
23	100				0	0
	700				0	0
	1300				0	0
	1900			9.8	1018.6	0
24	100			6.7	1022.6	0
	700			5.8	1025.8	0
	1300			8.1	1027.0	0
	1900		Gauge	6.1	1025.5	0
25	100			7.0	1024.6	0
	700			11.8	1024.1	0
	1300			19.3	1021.5	0
	1900		Inoperative	15.2	1019.7	0
26	100			15.1	1020.2	0
	700			14.6	1021.8	4
	1300			17.7	1022.0	0
	1900			9.4	1022.7	0
27	100			7.4	1025.9	0
	700			6.4	1031.3	0
	1300			4.9	1033.1	0
	1900			4.5	1032.4	0
28	100			5.4	1030.3	0
	700			6.4	1025.9	3
	1300			7.3	1018.6	0
	1900			12.0	1010.6	0
29	100			6.8	1012.0	0
	700		Hardware Error		50	
	1300			5.3	1014.6	0
	1900			4.6	1018.2	0
30	100			3.6	1020.2	0
	700			4.0	1022.8	0
	1300			6.2	1022.5	0
	1900			5.3	1020.9	0
31	100			5.3	1019.9	0
	700			6.3	1017.9	0
	1300			7.5	1016.4	0
	1900			7.3	1014.1	0
			Resultant	Mean	Mean	Total
		—	2	—	328	—
				—	6.5	—
					1017.6	—
						119

Wave Data

3

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

Mar 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.37	9.9			0.51	6.6	52	0.91	9.9
	0700	0.33	5.0			0.51	6.2	56	0.51	6.1
	1300	0.40	4.9			0.59	4.8	32	0.58	6.0
	1900	0.41	5.3			0.59	3.9	32	0.67	4.4
2	0100	0.41	4.7			0.75	4.4	60	0.88	4.4
	0700	0.98	5.2			1.59	8.2	88	1.83	7.4
	1300	0.93	6.3			1.44	8.9	80	1.49	8.1
	1900	0.77	7.6			1.15	8.2	76	1.25	7.8
3	0100	0.49	7.6			0.91	8.2	58	1.09	7.8
	0700	0.32	8.6			0.63	8.9	60	0.74	8.9
	1300	0.13	9.2			0.41	8.9	64	0.54	8.6
	1900	0.51	4.5			1.21	4.4	24	0.97	4.2
4	0100	0.82	6.8	Gauge		1.36	6.2	30	1.41	6.8
	0700	0.87	6.8			1.19	6.6	50	1.34	6.5
	1300	0.56	6.5			0.84	6.2	48	1.12	6.3
	1900	0.37	5.9			0.51	5.9	50	0.72	5.7
5	0100	0.14	5.2			0.37	7.1	72	0.43	7.8
	0700	0.16	4.9	Inoperative		0.35	8.9	74	0.40	7.6
	1300	0.11	7.8			0.35	7.6	80	0.39	7.2
	1900	0.41	7.0			0.67	7.1	108	0.85	6.3
6	0100	0.29	7.6			0.61	7.6	106	0.75	6.8
	0700	0.41	8.1			0.68	7.6	108	0.86	7.8
	1300	0.27	7.8			0.54	7.6	108	0.74	7.6
	1900	0.44	7.8			0.72	8.9	106	0.86	8.6
7	0100	0.35	9.9			0.65	8.9	106	0.83	8.6
	0700	0.43	10.7			0.70	10.8	106	0.75	11.2
	1300	0.49	10.7			0.84	10.8	104	0.96	9.9
	1900	0.65	10.3			1.20	4.6	28	1.20	10.3
8	0100	0.84	5.2			1.20	5.3	34	1.31	5.4
	0700	1.18	6.5			1.51	6.2	46	1.82	6.6
	1300	0.93	6.5			1.17	6.6	48	1.35	6.6
	1900	0.77	5.5			0.94	8.9	62	1.17	7.2
9	0100	0.84	6.0			1.09	6.2	34	1.25	6.0
	0700	0.96	6.1			1.17	6.6	48	1.41	6.6
	1300	0.68	5.9			0.88	6.6	50	1.00	7.2
	1900	0.52	5.9			0.74	5.9	46	0.84	6.5
10	0100	0.51	5.7			0.85	4.1	44	0.91	3.9
	0700	0.84	6.1			1.26	5.9	48	1.39	5.7
	1300	0.82	5.7			1.17	5.9	40	1.32	5.7
	1900	0.86	6.0			1.77	6.2	54	2.01	6.0

Table 4
Wave Data (continued)

Mar 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.95	6.0			1.65	5.9	60	1.83	6.3
	0700	0.81	6.3			1.98	6.2	60	2.08	5.9
	1300	1.11	7.6			2.78	7.1	60	2.87	7.0
	1900	0.99	10.3			2.96	9.8	82	2.94	9.2
12	0100	1.39	11.2			3.38	10.8	84	3.36	9.9
	0700	1.17	12.2			3.61	12.0	84	3.96	11.7
	1300	1.74	13.5			3.50	12.0	84	3.83	12.9
	1900	1.29	12.9			3.05	12.0	90	3.19	12.2
13	0100	1.67	12.9			2.51	13.6	80	2.58	12.9
	0700	1.23	12.9			2.20	12.0	66	2.14	12.9
	1300	1.29	12.2			1.96	12.0	68	1.89	10.7
	1900	1.15	11.2			1.73	12.0	58	1.70	12.2
14	0100	1.00	11.2	Gauge		1.41	10.8	96	1.43	11.7
	0700	0.76	10.7			1.16	10.8	60	1.16	11.2
	1300	0.60	10.3			1.05	10.8	56	1.07	9.9
	1900	0.43	9.5			0.87	10.8	58	0.90	10.3
15	0100	0.42	9.5			0.79	9.8	56	0.79	9.9
	0700	0.32	10.3			0.66	9.8	56	0.72	9.9
	1300	0.30	9.9	Inoperative		0.61	9.8	58	0.70	9.5
	1900	0.30	10.3			0.58	10.8	104	0.70	10.3
16	0100	0.28	8.6			0.60	9.8	60	0.64	9.5
	0700	0.41	8.9			0.60	9.8	110	0.80	10.7
	1300	0.29	9.5			0.56	9.8	58	0.69	9.9
	1900	0.36	10.7			0.72	10.8	60	0.82	10.3
17	0100	0.45	9.9			0.73	9.8	68	0.89	10.3
	0700	0.82	5.4			1.15	5.6	60	1.38	5.3
	1300	0.57	5.4			0.98	5.9	92	1.18	6.3
	1900	0.50	5.2			0.84	5.9	58	1.00	5.7
18	0100	0.35	7.4			0.78	6.2	80	0.83	5.7
	0700	0.35	9.5			0.64	6.2	64	0.71	6.1
	1300	0.28	7.8			0.59	8.2	86	0.63	8.9
	1900	0.39	4.3			0.66	4.4	60	0.85	4.2
19	0100	0.35	4.3			0.79	5.3	70	0.86	5.7
	0700	0.42	6.0			0.83	6.2	78	1.03	5.9
	1300	0.45	3.8			0.86	6.6	66	1.13	6.8
	1900	0.60	5.9			0.89	7.1	116	1.45	6.5
20	0100	0.27	9.9			0.59	8.9	106	0.89	8.9
	0700	0.34	8.6						0.93	2.9
	1300	0.21	8.6	Inoperative					0.63	9.9
	1900	0.29	8.3						0.64	8.3

Table 4
Wave Data (concluded)

Mar 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.16	8.6						0.51	8.1
	0700	0.19	8.5						0.47	9.5
	1300									
	1900									
22	0100									
	0700									
	1300	inoperative		inoperative		inoperative			inoperative	
	1900									
23	0100									
	0700									
	1300	0.20	4.6							
	1900	0.17	12.9							
24	0100	0.16	13.5							
	0700	0.13	12.2							
	1300	0.36	4.5							
	1900	0.22	4.5							
25	0100	0.26	6.8							
	0700	0.23	14.3						0.55	13.5
	1300	0.28	14.3						0.78	13.5
	1900	0.26	13.5						0.76	13.5
26	0100	0.26	13.5	inoperative		inoperative			0.60	12.9
	0700	0.28	6.6						0.63	6.3
	1300	0.30	6.6						0.65	7.0
	1900	0.23	6.9						0.55	12.9
27	0100	0.95	2.1						0.68	12.2
	0700	1.10	5.0						1.61	5.0
	1300	1.18	7.2						2.17	7.0
	1900	0.91	6.6						1.61	6.6
28	0100	1.02	5.7						1.66	5.3
	0700	1.03	6.0						2.16	5.9
	1300	1.34	7.0						2.16	6.8
	1900	1.27	8.1						2.13	8.3
29	0100	0.98	8.1						1.72	8.3
	0700	0.84	8.5						1.31	8.3
	1300	0.84	9.5	inoperative		1.29	9.7	0	1.31	8.9
	1900	1.08	10.3			1.69	10.8	56	1.62	10.3
30	0100	1.23	11.2			2.16	10.8	56	2.29	10.7
	0700	1.17	12.2			2.26	12.0	84	2.34	10.7
	1300	1.38	13.5			2.14	13.6	72	2.13	12.2
	1900	1.13	12.9			1.54	12.0	66	1.79	12.9
31	0100	0.94	11.7			1.28	12.0	72	1.38	12.2
	0700	0.61	10.7			1.08	10.8	60	1.17	11.7
	1300	0.56	10.7			1.01	10.8	60	1.13	11.2
	1900	0.46	10.3			0.90	10.8	84	1.01	10.3
Mean		0.63	8.3	0.00	0.0	1.17	8.4	66	1.26	8.4
Std dev		0.38	2.8	0.00	0.0	0.73	2.5	23	0.72	2.6

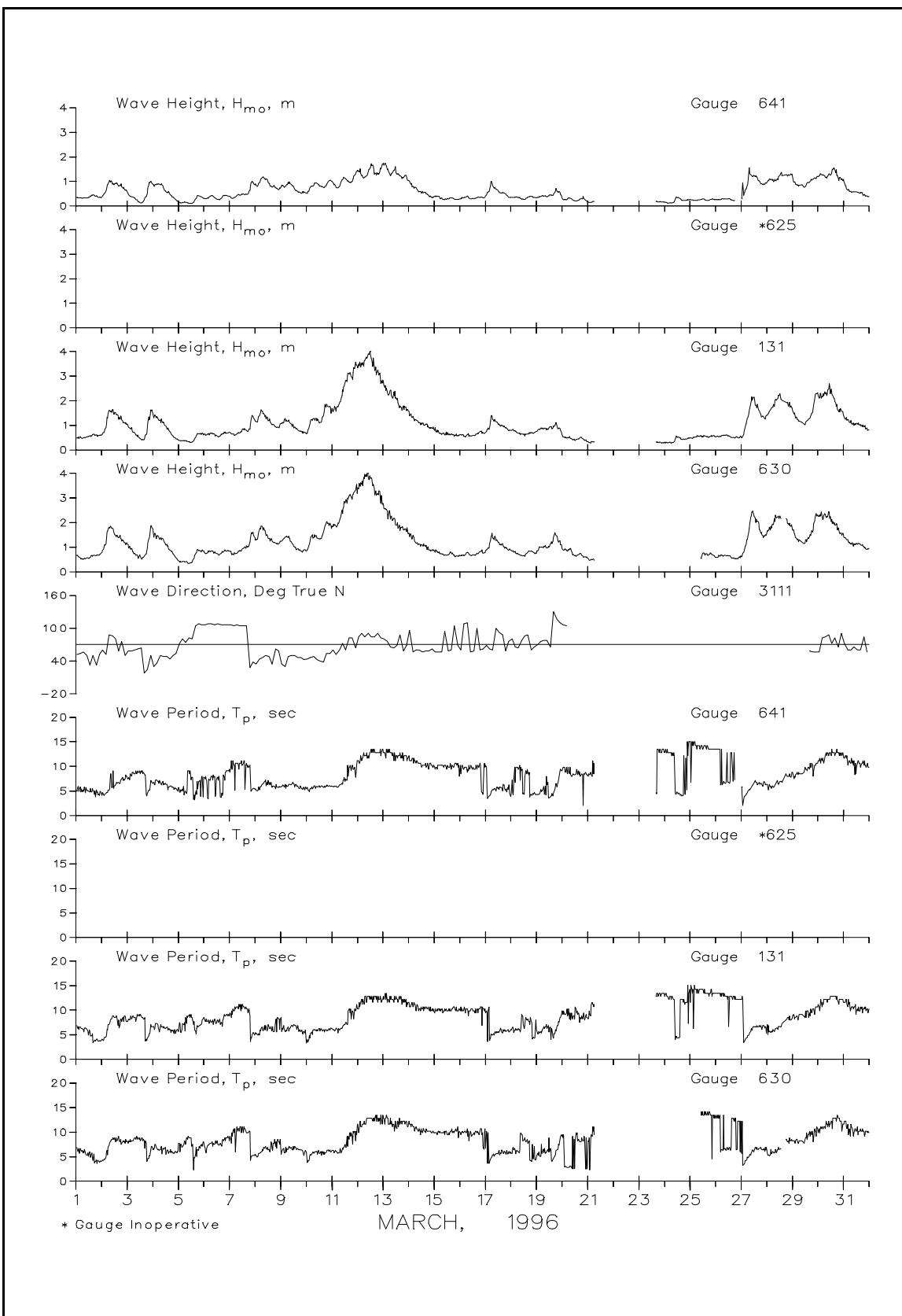


Figure 5. Wave Heights and Periods

Current Data

4

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 3539

MARCH 1996																	
	Cross Shore					Long Shore					Cross Shore						
Day	Time	Cross Speed	Long Speed	Dir	Day	Time	Cross Speed	Long Speed	Dir	Day	Time	Cross Speed	Long Speed	Dir			
		Shore	Shore	Dir			Shore	Shore	Dir			Shore	Shore	Dir			
1	100	-1	1	2	105		1300	-3	48	49	155	22	100				
	700	0	8	8	154		1900	-4	63	63	156		700		inoperative		
	1300	0	1	1	117	12	100	0	50	50	159		1300				
	1900	2	8	9	170		700	-1	36	36	157		1900	4	3	5	209
2	100	-2	18	18	151		1300	0	32	32	159	23	100	2	17	17	166
	700	-1	26	26	155		1900	0	17	17	158		700	0	19	19	159
	1300	-1	13	13	151	13	100	0	-3	4	353		1300	2	11	11	169
	1900	0	9	9	157		700	-2	1	3	87		1900	0	10	10	161
3	100	2	5	5	180		1300	-2	-7	9	359	24	100	3	3	4	212
	700	0	0	0			1900	-2	1	3	84		700	0	10	10	161
	1300	4	-3	5	296	14	100	-1	-1	3	14		1300	1	7	7	169
	1900	-4	17	18	143		700	0	9	9	160		1900	4	1	4	235
4	100	-12	20	24	127		1300	1	4	4	172	25	100	4	0	4	263
	700						1900	2	7	7	173		700	2	0	2	251
	1300					15	100	1	-1	2	320		1300	2	1	2	228
	1900						700	0	2	2	155		1900	4	-1	5	275
5	100											26	100	5	-1	5	272
	700						1900	-1	0	2	62		700	5	-6	9	305
	1300					16	100	-3	-4	7	17		1300	3	-3	5	301
	1900						700	-4	5	7	117		1900	2	0	2	243
6	100	inoperative					1300	-1	2	3	115	27	100	2	6	7	180
	700						1900	0	8	8	157		700	0	18	18	160
	1300					17	100	-5	3	7	96		1300	-6	55	56	153
	1900						700	-1	20	21	156		1900	4	22	23	169
7	100						1300	2	-2	4	311	28	100	3	17	17	169
	700						1900	5	19	19	174		700	0	19	19	160
	1300					18	100	0	8	8	155		1300	-1	23	23	156
	1900						700	-1	0	2	34		1900	0	23	23	158
8	100						1300	1	17	17	163	29	100	0	22	22	160
	700						1900	1	17	17	163		700	0	21	21	161
	1300					19	100	4	16	17	173		1300	2	14	14	166
	1900						700	0	0	0			1900	1	37	37	161
9	100						1300	0	16	16	158	30	100	4	31	31	168
	700						1900	9	7	11	213		700	4	19	20	173
	1300					20	100	5	-8	10	310		1300	2	7	8	176
	1900						700	3	-15	17	330		1900	0	11	11	162
10	100						1300	4	-11	12	323	31	100	4	6	8	193
	700						1900	6	-2	7	275		700	0	7	7	162
	1300					21	100	4	0	4	249		1300	2	7	7	176
	1900						700	1	-5	6	330		1900	2	9	9	171
11	100						1300						1900				
	700						1900						inoperative				

KEY:

+cross-shore = offshore, cm/sec
 -cross-shore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Mar 1996												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	-10	8	13	213	-22	21	30	206	South	27	N	
2	6	61	61	154	0	29	29	160	South	18	N	
3	32	-25	41	31	20	-20	28	25	North	43	S	
4	-7	24	25	177	-23	47	52	187	South	55	N	
5	9	-36	37	354	2	-19	19	346	South	9	S	
6	4	-41	41	346	22	-55	60	2	North	61	N	
7	-5	10	11	250	-9	-16	18	309	North	49	N	
8	6	55	56	154	0	76	76	160	South	88	N	
9	7	47	47	151	-25	55	61	184	South	91	S	
10	-6	30	31	171	0	51	51	160	South	37	N	
11	9	87	88	154	10	68	68	151	South	40	N	
12	0	55	55	160	-5	102	102	163	North	0		
13	0	55	55	160	-5	102	102	163	North	0		
14	4	23	24	151	1	27	27	157	North	43	N	
15	0	0	0		36	-13	39	50	North	58	N	
16	6	-10	12	13	57	-29	64	43	South	37	N	
17	0	36	36	160	20	10	23	70	South	44	N	
18	0	32	32	160	0	24	24	160	North	40	N	
19	0	36	36	160	0	25	25	160	North	6	N	
20	0	34	34	160	18	9	20	70	North	12	N	
21	24	-41	47	11	8	-27	28	357	North	6	S	
22	20	13	24	104	11	4	12	88	North	3	S	
23	2	23	23	154	12	23	26	133	North	61	S	
24	0	51	51	160	12	16	20	125	North	30	S	
25	-15	38	41	182	-1	15	15	163	South	6	S	
26	1	-16	16	343	37	-18	41	43	South	27	N	
27	5	-23	24	351	1	-28	28	343	South	29	N	
28	-5	47	47	166	-19	55	59	179	North	49	N	
29	-3	28	28	166	-18	61	64	177	North	43	N	
30	25	55	61	136	0	36	36	160	North	37	N	
31	0	51	51	160	-26	44	51	191	North	43	N	

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

Visual Observations

5

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Mar 1996							
Day	Time	Wave Approach Angle at Pier End deg from True N		Width of Surf Zone,m	Water Characteristics at Pier End		
		Primary	Secondary		Temp.,C	Density g/cc	Secchi Vis.,m
1	0734	40		26	5.0	1.0224	2.4
2	0805	50	80	216	5.0	1.0200	1.5
3	0811	70		26	4.4	1.0221	1.2
4	0730	35		151	4.2	1.0241	3.7
5	0730	130		15	4.4	1.0243	1.8
6	0730	130		49	5.6	1.0256	2.1
7	0736	105		50	6.1	1.0256	1.5
8	0736	20		160	5.6	1.0254	1.8
9	0745	5		162	4.4	1.0250	1.2
10	0836	10		163	3.6	1.0249	1.8
11	0730	35		287	3.6	1.0216	1.2
12	0724	50	70	788	3.9	1.0151	0.6
13	0738	80	70	329	3.9	1.0213	0.3
14	0737	75		191	4.4	1.0244	0.6
15	0715	90		34	4.4	1.0251	0.9
16	0730	20	60	24	5.0	1.0253	1.2
17	0800	55		62	6.1	1.0221	1.5
18	0740	55		27	6.4	1.0204	1.5
19	0730	70		26	6.4	1.0143	1.8
20	0725	110	30	26	4.7	1.0260	1.2
21	0715	80		8	5.6	1.0266	2.1
22	0720	10		41	5.8	1.0264	3.0
23	0835	20		6	5.6	1.0236	3.4
24	0638	none	visible	0	5.8	1.0220	3.4
25	0804	30	100	11	6.9	1.0222	4.0
26	0715	120	90	18	6.1	1.0264	1.8
27	0700	45		235	6.4	1.0261	1.2
28	0730	80	50	238	7.5	1.0156	0.6
29	0745	60	25	168	7.2	1.0205	0.3
30	0820	70		265	6.7	1.0220	0.3
31	0825	70		154	6.9	1.0225	0.3

Water Levels

6

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

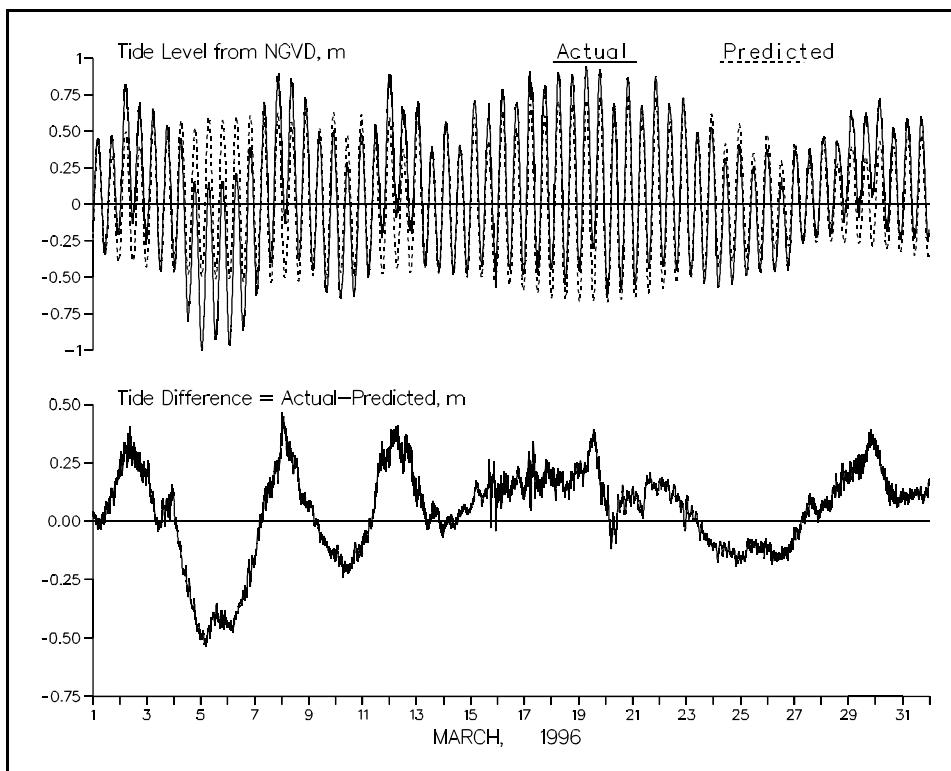


Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

MAR 1996 Tide Levels																		
Day	High			Low			Mean	Range	High			Low			Mean	Range		
	Time	m	Day	Time	m	Day			Time	m	Day	Time	m	Day				
1	0436	0.45	1	0000	-0.19		0.22	0.64	16	1730	0.70	16	1118	-0.45	0.14	1.15		
1	1648	0.47	1	1048	-0.34		0.06	0.82	17	0448	0.91	16	2236	-0.48	0.22	1.39		
2	0454	0.82	1	2248	-0.21		0.30	1.03	17	1754	0.82	17	1136	-0.48	0.18	1.30		
2	1736	0.69	2	1112	-0.13		0.27	0.83	18	0600	0.90	18	0000	-0.45	0.22	1.35		
3	0536	0.65	2	2336	-0.28		0.18	0.93	18	1848	0.89	18	1230	-0.55	0.19	1.44		
3	1812	0.54	3	1242	-0.46		0.05	1.00	19	0712	0.95	19	0106	-0.46	0.25	1.41		
4	0612	0.45	4	0106	-0.45		-0.01	0.90	19	1848	0.92	19	1330	-0.31	0.29	1.23		
4	1836	0.16	4	1248	-0.80		-0.32	0.96	20	0724	0.69	20	0130	-0.64	0.02	1.33		
5	0706	0.15	5	0100	-1.00		-0.43	1.15	20	2006	0.87	20	1400	-0.59	0.14	1.45		
5	1900	0.16	5	1254	-0.93		-0.38	1.09	21	0812	0.68	21	0230	-0.55	0.09	1.23		
6	0748	0.22	6	0154	-0.97		-0.37	1.19	21	2036	0.88	21	1424	-0.44	0.22	1.32		
6	2006	0.39	6	1348	-0.86		-0.22	1.25	22	0836	0.69	22	0306	-0.43	0.14	1.12		
7	0824	0.70	7	0142	-0.62		0.04	1.32	22	2112	0.73	22	1518	-0.46	0.14	1.18		
7	2106	0.89	7	1448	-0.40		0.26	1.30	23	0948	0.49	23	0354	-0.48	0.00	0.97		
8	0848	0.86	8	0318	-0.13		0.35	0.99	23	2206	0.53	23	1600	-0.55	-0.01	1.08		
8	2054	0.73	8	1536	-0.38		0.17	1.12	24	1030	0.31	24	0430	-0.57	-0.13	0.88		
9	0918	0.47	9	0336	-0.46		0.00	0.93	24	2242	0.41	24	1636	-0.55	-0.08	0.96		
9	2224	0.51	9	1612	-0.61		-0.07	1.11	25	1118	0.26	25	0506	-0.49	-0.12	0.75		
10	1018	0.29	10	0418	-0.65		-0.19	0.94	25	2354	0.38	25	1742	-0.47	-0.04	0.85		
10	2236	0.49	10	1624	-0.64		-0.07	1.12	26	1230	0.18	26	0636	-0.46	-0.15	0.65		
11	1130	0.55	11	0442	-0.50		0.02	1.05	27	0030	0.37	26	1812	-0.46	-0.02	0.83		
12	0024	0.89	11	1712	-0.23		0.34	1.12	27	1330	0.38	27	0718	-0.27	0.05	0.65		
12	1124	0.67	12	0612	-0.09		0.30	0.76	28	0224	0.47	27	1906	-0.23	0.12	0.70		
13	0106	0.70	12	1948	-0.20		0.24	0.90	28	1400	0.43	28	0812	-0.21	0.14	0.65		
13	1400	0.40	13	0742	-0.42		-0.01	0.82	29	0248	0.64	28	2000	-0.13	0.27	0.77		
14	0206	0.56	13	1948	-0.46		0.05	1.02	29	1542	0.63	29	0942	-0.09	0.29	0.72		
14	1430	0.41	14	0830	-0.48		-0.02	0.89	30	0406	0.73	29	2106	0.04	0.37	0.69		
15	0342	0.71	14	2036	-0.47		0.13	1.18	30	1554	0.52	30	1006	-0.19	0.17	0.71		
15	1612	0.69	15	0936	-0.43		0.10	1.12	31	0424	0.59	30	2200	-0.25	0.17	0.83		
16	0424	0.79	15	2224	-0.57		0.19	1.36	31	1648	0.61	31	1036	-0.24	0.17	0.84		

Bathymetry

7

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in February 1996 and the survey(s) in March 1996 on profile line 188, located 517 m south of the pier.

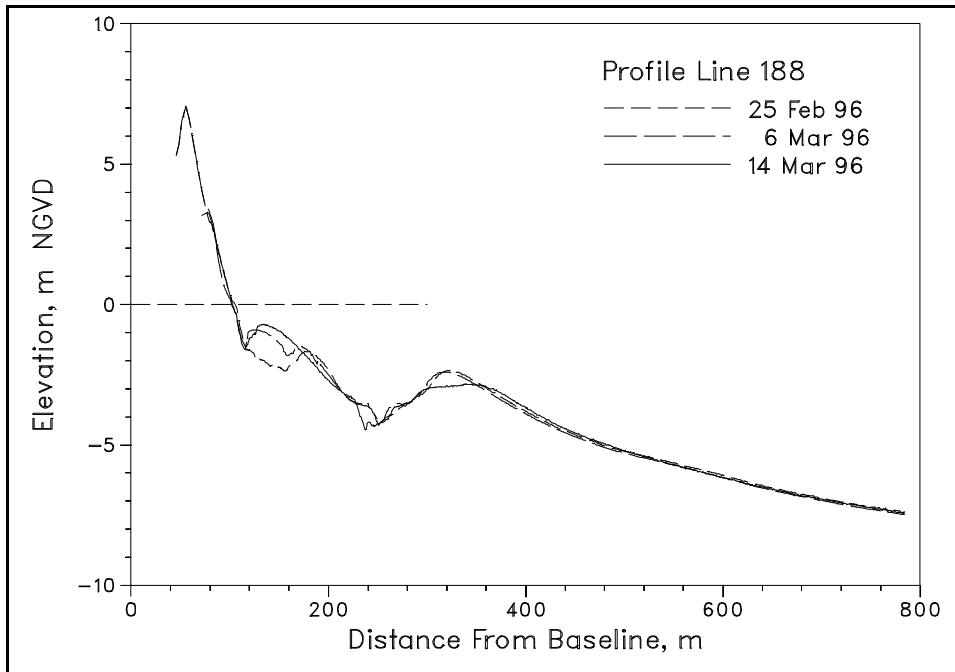


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1996. Cross-hatched areas indicate changes to the annual envelope which occurred in March.

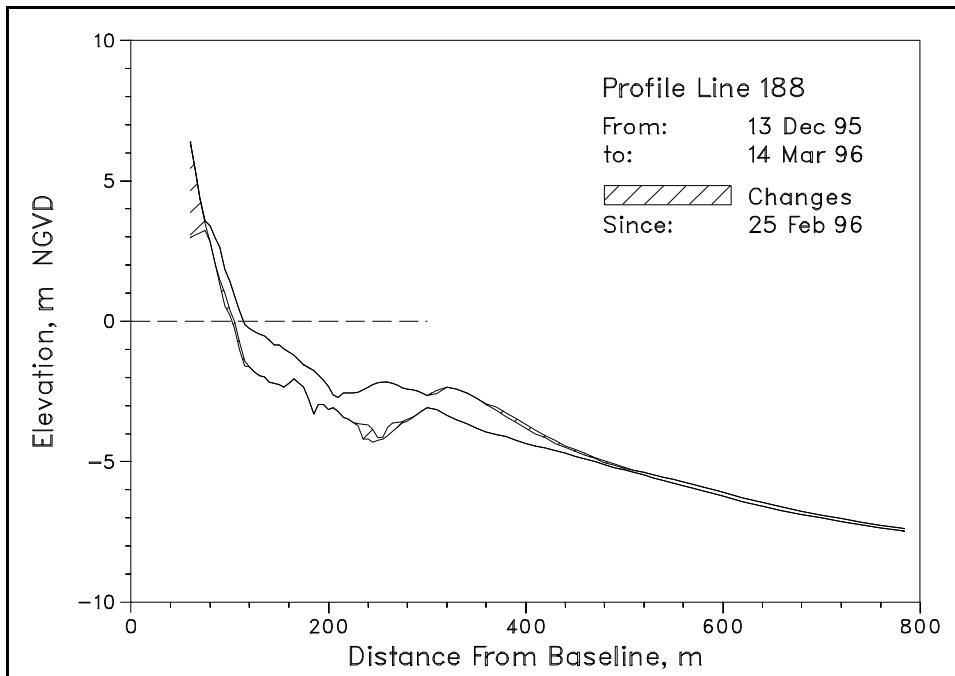
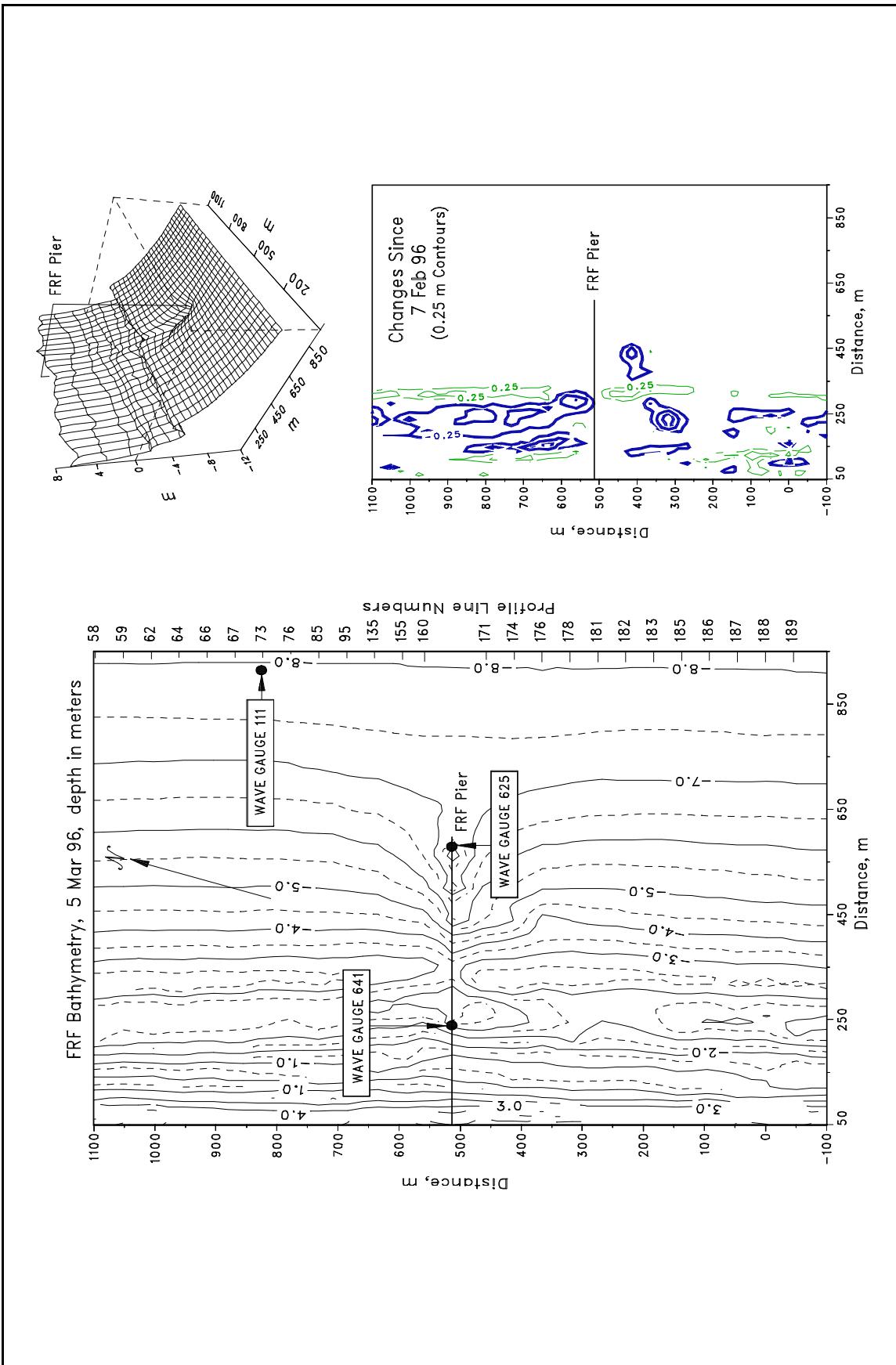


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 5 March. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



Special Events

8

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier exceeded 2 m.

	<u>Start</u>	<u>End</u>
10 Mar (1900)	13 Mar (1108)	
27 Mar (0842)	27 Mar (1600)	
28 Mar (0700)	28 Mar (1900)	
29 Mar (2042)	30 Mar (1516)	

B. Storm Synopsis.

10-13 Mar Northeasterly winds were funneled between a high pressure system over Pennsylvania and a low pressure system moving northward about 320 km offshore Cape Hatteras. Maximum onshore winds (NE) reached 19 m/s at 1408 EST on 11 March. The maximum H_{mo} , at gauge 630, reached 4.1 m ($T_p=12.8$ s) at 0916 EST on 12 March. There was no precipitation.

27-30 Mar Northeasterly winds were associated with a high pressure system over the Great Lakes. The anemometer was non-operational during this time. The maximum H_{mo} , at gauge 630, reached 2.5 m ($T_p=6.2$ s) at 1108 EST on 27 March. By the morning of 28 March, winds were funneled between the high, which was now over New England, and a low that had moved eastward, over Alabama. The maximum H_{mo} , at gauge 630, reached 2.3 m ($T_p=6.6$ s) at 1216 EST on 28 March. By the morning of the 29th, the storm had passed over the FRF and was headed out to sea. The maximum H_{mo} , at gauge 630, reached 2.4 m ($T_p=12.2$ s) at 1000 EST on 30 March.
There was a total of 53 mm of precipitation.